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(54) THREE-PHASE TRANSFORMER

(71) We, UNELEC, a French corporation, of 38 avenue Kleber, 75784 Paris Cedex 16, France, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a three-phase transformer comprising a magnetic core, having three links extending radially from the longitudinal axis of the core at 120 degree spacings and yoke portions connecting the free ends of the limbs, and winding assemblies, comprising high and low voltage windings, carried by the limbs.

Transformers of this kind are disclosed in the present Applicants' patent No. 1,361,436 and in their application No. 22451/73 (Serial No. 1415209). Certain electrical characteristics leads, for reasons of economy, to the determining of rules concerning the dimensions of the transformers. Thus, the ratio of the average radial dimensions H*m* (evaluated in mm) of the winding assemblies of the applicants' previous transformers to the fifth root of the power (evaluated in KVA) is greater than 75 and very often greater than 100.

The invention provides a transformer which, while retaining identical electrical characteristics, has a value of H*m* different from that just specified, the value being such that, for equal power, the required quantities of magnetic material and of copper, hence the cost, may be reduced.

According to the invention there is provided a three-phase transformer comprising a magnetic core, having three limbs extending radially from the longitudinal axis of the core at 120 degree spacings and yoke portions connecting the free ends of the limbs, and winding assemblies, comprising high and low voltage windings carried by said limbs, the average dimensions, H*m* in millimetres, of the winding assemblies in the radial direction of the core being in the range thirty times to sixty times the fifth root of the rated power, P in kilo-volt-amperes, of the transformer.

For a better understanding of the present invention and to show how the same may be carried into effect, reference will now be made, by way of example, to the accompanying drawings, in which:

Figure 1 is a diagrammatic plan view of one form of three-phase star-connected transformer,

Figure 2 is a diagrammatic cross-section view taken along the line AB of Figure 1,

Figure 3 shows a diagrammatic plan view of another three-phase star-connected transformer, and

Figure 4 is a diagrammatic cross-sectional view taken along the line A'B' of Figure 3.

Figure 1 shows a three-phase transformer whose magnetic core comprises three limbs 1, extending radially from the longitudinal axis of the core and arranged at 120 degrees to one another, and a hexagonal yoke 2 of which portions connect the ends of the limbs. As in the case of the transformer disclosed in application No. 22451/73 (Serial No. 1415209) the core comprises a plurality of metal sheets arranged in stacked horizontal layers to provide a core structure, the respective layers being formed by an assembly of abutting sheets so arranged that, for any two adjacent layers, no joint in either layer between abutting sheets coincides with any such joint in the other layer. It should be noted that the joints have not been shown in Figure 1. Winding assemblies 3, which may be made of copper, are arranged at 120 degrees from one another and surround the magnetic limbs 1. The turns of these winding assemblies are then vertical. The winding assemblies 3 comprise low-voltage windings 31 and high-voltage windings 32 and they are coaxial. The average dimension of these winding assemblies in the radial direction of the core is H*m*. The width of the magnetic limbs 1 in any cross-sectional plane of the magnetic core (or in the horizontal plane of Figure 1) is $2a_2$. The length of the limbs in the axial direction of

the core is a_1 (Figure 2) and is the thickness of the stack of horizontally arranged metal sheets. The low-voltage windings 31 have, as their thickness in the tangential direction of the core, l_2 (in millimetres) and the high-voltage windings 32 have, as their corresponding thickness, l_1 (in millimetres).

Figure 3 shows a three-phase transformer similar to that in Figure 1 but constructed in the manner disclosed in application No. 56355/71 (Serial No. 1,361,436) so that the core comprises three magnetic core members 4 each of which provides a magnetic circuit and has two adjoining rectilinear side portions and a yoke portion connecting the free ends of the side portions, each side portion being arranged against a rectilinear side portion of a neighbouring core member. Each pair of adjacent side portions thereby provides a respective one of the limbs of the magnetic core, which radiate at 120 degree in spacings from the longitudinal axis of the core. The core members 4 consist of vertical metal sheets and, as in the previous case, the three winding assemblies are wound around the respective limbs of the core. The winding assemblies each comprise high-voltage windings 52 and low-voltage windings 51, and they are arranged at 120 degrees from one another (as mentioned previously) in relation to the central axis of the core as in the example of Figure 1. The width of the limbs in any cross-sectional plane of the magnetic core (or in the plane of Figure 3) is $2a_2$, and the average dimension of the winding assemblies 5 in the radial direction of the core is Hm. Figure 4 shows that a_1 is the length of the limbs in the axial direction of the magnetic core 4. l_1 is the thickness of the high-voltage windings in the tangential direction of the core and l_2 is the corresponding thickness of the low-voltage windings.

The dimensioning of the core is determined as follows:

Firstly, Hm is determined from:

$$30\ \sqrt[5]{P} \leqslant Hm \leqslant 60\ \sqrt[5]{P} \qquad (1)$$

where P is the rated output power of the transformer in KVA, Hm being measured in millimeters. Preferably, Hm will be in the range forty to fifty times the fifth root of P.

Another construction rule may be compiled with for an optimised transformer:

$$2 \leqslant Hm/(l_1+l_2) \leqslant 4 \qquad (2)$$

where l_1 and l_2 are in millimetres. A preferential value of the given ratio is that it should be in the range 2.5 to 3.5.

Another rule is complied with simultaneously with the previous two:

$$0.6\ 2\sqrt{P} \leqslant Z \leqslant 2\sqrt{P} \qquad (3)$$

where Z is the ratio between the rated voltage of any one of the winding assemblies to the number of turns which that assembly comprises, Z being measured in volts per turn, and P being the rated output power of the transformer in KVA. Preferably Z is between 0.7 $2\sqrt{P}$ and 0.9 $2\sqrt{P}$.

Finally, the ratio of the two dimensions a_1, a_2 of the magnetic core should preferably satisfy the requirement:

$$1 \leqslant \frac{a_1}{2a_2} \leqslant 2 \qquad (4)$$

The advantage of complying with the above constructional rules is that the rated power of the transformer being considered as constant, the cost and possibly the bulk of the transformers described may be reduced.

The transformer having dimensions optimised by the four construction rules set forth above may be used for all powers.

In the above description, it has been supposed that the transformer has the three radial axes of the limbs in the same horizontal plane. Clearly, these three axes may alternatively be arranged in a vertical plane.

WHAT WE CLAIM IS:—

1. A three-phase transformer comprising a magnetic core, having three limbs extending radially from the longitudinal axis of the core at 120 degrees spacings and yoke portions connecting the free ends of the limbs, and winding assemblies, comprising high and low voltage windings carried by said limbs, the average dimensions, Hm in millimetres, of the winding assemblies in the radial direction of the core being in the range thirty times to sixty times the fifth root of the rated power, P in kilo-volt-amperes, of the transformer.

2. A transformer according to claim 1, wherein Hm is in the range forty times to fifty times the fifth root of P.

3. A transformer according to claim 1 or 2, wherein the ratio of Hm in millimetres to the sum of the respective thicknesses l_1 and l_2, in millimetres, of the high-voltage and low-voltage windings, taken in the tangential direction of the core, is in the range 2 to 4.

4. A three-phase transformer according to claim 3 wherein the ratio of Hm to the sum of l_1 and l_2 is in the range 2.5 to 3.5.

5. A transformer according to claim 3 or 4, wherein the ratio Z of the rated voltage of any one of the winding assemblies to the number of turns of that winding assembly is in the range six tenths of the square root of the power P to the square root of the rated power P.

6. A transformer according to any preced-

ing claim, wherein the ratio between the length a_1 of the limbs, taken in the axial direction of the core, to the width $2a_2$ of the limbs in any cross-sectional plane of the core is in the range 1 to 2.

7. A three-phase transformer substantially as hereinbefore described with reference to Figures 1 and 2 or Figures 3 and 4 of the accompanying drawings.

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1424982 COMPLETE SPECIFICATION

2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

FIG.1

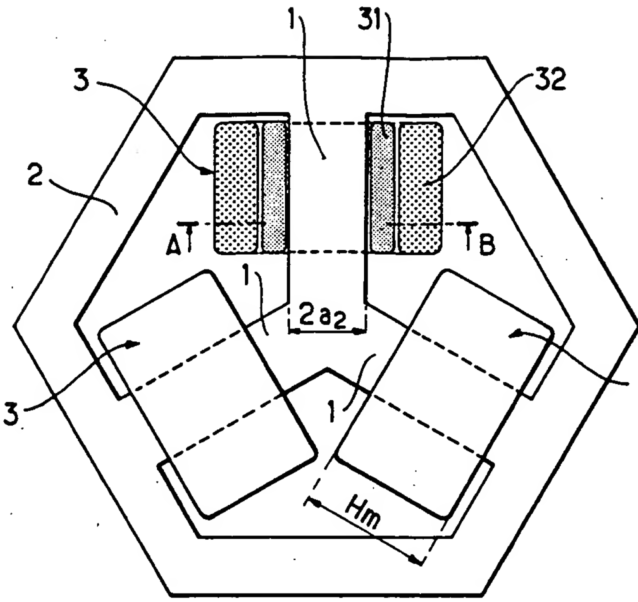

FIG.2

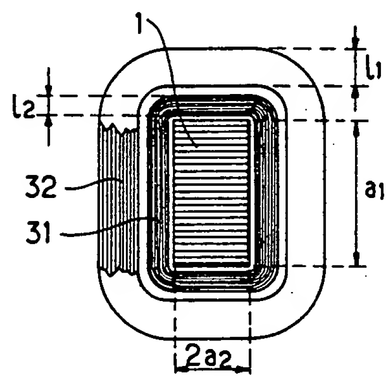

FIG.3

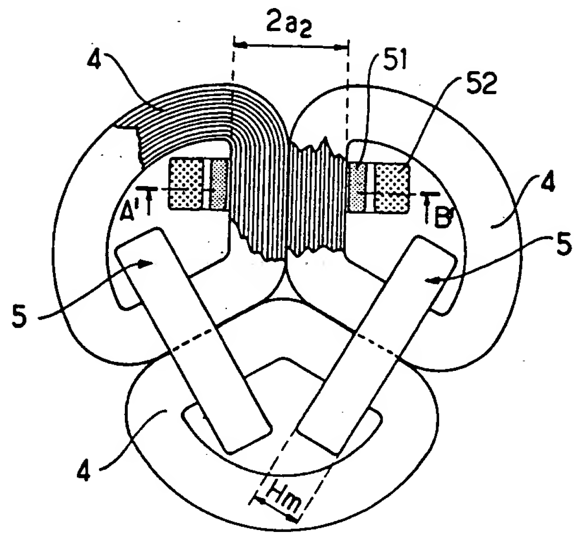

FIG.4